

Exploration and mining in the Southwest Region, British Columbia



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1. Introduction

The Southwest Region (Fig. 1) has a long history of mining. This history includes: the use of native copper by aboriginal people; silver, gold and coal mining by the mid 19th century; mining of iron in the mid 20th century; and substantial copper production throughout the 20th century. Although mining and exploration for metal and coal continue in the region, most mining is for construction materials, mainly aggregates for local markets.

The area has one major polymetallic metal mine, **Myra Falls** (Nyrstar N.V.), one coal mine, **Quinsam** (ERP Compliant Fuels LLC), and numerous industrial minerals and aggregate operations. Both Myra Falls and Quinsam were on care and maintenance until the summer of 2017 when, supported by higher commodity prices, they were put back into production.

Although Nyrstar N.V. was in the process of selling the Myra Falls mine, they ultimately decided to invest in, and operate, the property. The Quinsam mine was purchased by ERP Compliant Fuels LLC in 2017 who resumed production in October. Mine site exploration began at Myra Falls late in the year. A permitted program by Quinsam was deferred but could take place in 2018.

There were two significant off-lease exploration drilling programs in 2017 (**Surespan Gold** and **North Island**) and one major project (North Island) released a preliminary economic assessment. As in 2016, about 25 active exploration projects were tracked; most were small scale. BURNCO Rock Products Ltd.'s large aggregate project on Howe Sound, **BURNCO Aggregate**, is in the environmental assessment review stage, and a draft assessment report is completed. Polaris Materials Corporation sought a permit amendment for its Orca quarry to allow for production of a crushed basalt product near the existing quarry. Polaris shareholders have since approved sale of the company to U.S. Concrete Inc.

As in 2016, estimates for exploration expenditures, drilling programs, and other metrics were captured in the British Columbia Mineral and Coal Exploration Survey, a joint initiative of the Province of British Columbia Ministry of Energy, Mines and Petroleum Resources, the Association for

Mineral Exploration in British Columbia, and Ernst and Young LLP. For the Southwest Region, exploration expenditures were estimated at \$9.3 million and exploration drilling was estimated at approximately 10,600 m (Clarke et al., 2018; Ernst & Young LLP, in press).

Expenditures and exploration drilling are up over the previous year's \$2 million and 3800 m but still reflect a small number of major exploration projects and reduced activity at Quinsam and Myra Falls until late in the year.

2. Geological overview

Metallogeny in British Columbia is closely linked to the tectonic evolution of the Canadian Cordillera, first as an accretionary orogen consisting of allochthonous terranes that were welded to and deformed with the western margin of ancestral North America primarily during the Jurassic and then as the site of post-accretionary tectonism and magmatism (e.g., Nelson et al., 2013).

The Southwest Region includes parts of the Insular, Coast, and Intermontane physiographic regions. Most of the area is underlain by rocks of the Wrangell terrane and the Coast Plutonic complex (Fig. 1). Wrangellia is a Devonian to Jurassic island arc terrane that underlies most of Vancouver Island and Haida Gwaii. The oldest rocks on Vancouver Island are Devonian volcanic arc andesites, basalts, breccias, tuffs and tuffaceous sediments of the Sicker Group and allied intrusive rocks, overlain by Mississippian-Permian limestones, argillites, and minor conglomerate of the Buttle Lake Group. This Paleozoic basement is exposed in two major uplifts on southern and central Vancouver Island. The Cowichan anticlinorium and the Buttle Lake anticlinorium host past and present volcanogenic massive sulphide polymetallic producers at Mount Sicker and **Myra Falls**.

Unconformably overlying the Paleozoic rocks are Middle to Upper Triassic oceanic flood basalts and related sedimentary rocks of the Vancouver Group. The upper part of the Vancouver Group contains numerous skarn occurrences adjacent to Jurassic intrusions (Island Plutonic suite). The Tasu past producer on Haida Gwaii is one of the larger examples of numerous iron

Fig. 1. Mines and selected exploration projects, Southwest Region, 2017. Terranes from Cui et al. (2017).

and iron-copper skarns. Between 1914 and 1983, it produced 12 Mt of iron concentrate as well as copper, gold and silver.

The Vancouver Group is overlain by arc rocks of Bonanza Group (Upper Triassic-Middle Jurassic), which consist of a volcano-sedimentary succession and subaerial basalt to rhyolitic flows and tuffs (Nixon and Orr, 2007). The Bonanza Group north of Holberg Inlet host the past-producing Island Copper Cu-Mo-Au porphyry deposit and other undeveloped porphyry and epithermal prospects where they are intruded by Island Plutonic suite granodiorite and quartz diorite.

On the east coast of Vancouver Island, in the Strait of Georgia, and on the western mainland, Wrangellia is buried by rocks of the Nanaimo Group, an Upper Cretaceous continental to marine molassoid succession containing debris derived from unroofing of the Coast Belt and northern Cascades (Mustard, 1994). The Comox Formation, the basal unit of the Nanaimo Group, hosts economically important coal deposits that were mined historically in the Nanaimo area now near Campbell River.

The Coast Mountain range is underlain by the Coast Plutonic complex, a large northwest-trending batholith consisting largely of diorite, quartz diorite, tonalite and granodiorite calc-alkaline rocks with less abundant high-grade metamorphic rocks. For the most part, uplift and erosion have removed the levels at which epithermal and porphyry style mineralization form, with some exceptions. At the southern end of the Coast Plutonic complex, economically important deposits occur in pendants of the Gambier Group, overlapping Late Jurassic to Mid-Cretaceous arc-related volcanic and sedimentary rocks. The most productive of these deposits was the Britannia mine, a Kuroko-type polymetallic volcanogenic massive sulphide deposit that produced 517,000 t of Cu along with Zn, Ag, Au, Pb and Cd between 1905 and 1974. At the southeastern edge of the Coast ranges, the Late Cretaceous Giant Mascot ultramafic-mafic intrusive suite (Manor et al., 2014, 2015, 2016, 2017) hosts the province's only past producing nickel mine, Giant Mascot Nickel, which operated between 1958 and 1974.

Eocene to Miocene ancestral Cascades arc magmatism extended as far northward as southwestern British Columbia, as does present day Cascades magmatism. Evidence of forearc Paleocene to Miocene magmatism can be traced from southern Oregon through Alaska (Madsen et al., 2006). Mount Washington Copper (Eocene) produced 3548 t of Cu, 131 kg Au and 7235 kg Ag. Catface Copper (Eocene) has a significant undeveloped resource. Other presumably Cenozoic targets include Giant Copper and Okeover. Harmony on Graham Island, Haida Gwaii is a Miocene epithermal deposit with a significant undeveloped gold resource. More recent Cascades magmatism has produced pumice and other volcanic rocks quarried for construction, landscaping, and other applications. The Mount Meager area has also been investigated as a possible source of geothermal energy.

On Vancouver Island, the western and southern margins of Wrangellia are structurally juxtaposed with the Pacific Rim terrane, which consists of possible mélange deposits

(Rusmore and Cowan, 1985; Brandon, 1989) and the Leech River complex, an assemblage of greenschist- to amphibolite-grade mudstones, sandstones, and mafic volcanic rocks cut by granitic bodies (Groome et al., 2003). Slate and siltstone is quarried for building stone in the Leech River complex. The Leech River has been an active placer gold camp since 1864. Gold quartz veins have been the subject of recent exploration near the Leech River fault, along the southern margin of the terrane.

The Crescent terrane represents Eocene accretion of Late Cretaceous or Paleocene to Early Eocene seamounts. The Leech River fault marks the boundary of Pacific Rim and Crescent terranes. The Metchosin Igneous complex, a partial ophiolite and northernmost extent of the Coast Range basalt province (Massey, 1986), contains three tholeiitic intrusion-hosted past producers of copper and precious metals, the most significant of which was the Sunro mine.

The southeastern Coast Belt, north of the international border is underlain by the Nooksack-Harrison and Chilliwack terranes (equivalent to Stikinia; Monger and Struik, 2006), and the Bridge River, Cadwallader and Methow terranes, allied with the main Cache Creek terrane (Fig. 1). These represent slices of oceanic and arc-related rocks enclosed between Intermontane and Insular terranes during Middle Jurassic to Middle Cretaceous regional sinistral faulting (Bustin et al., 2013; Monger and Brown, in press). Gambier Group equivalent overlap deposits and parts of the Nooksack-Harrison terrane are prospective for VMS mineralization. The Coquihalla Serpentine belt, along the Hozomeen fault between the Bridge River terrane to the west and the Methow terrane to the east, hosts several gold prospects and five past producers including the Carolin mine, which operated between 1981 and 1984.

Tectonic uplift, erosion, and glaciation produced sand and gravel deposits important to the construction and transportation industries of the Lower Mainland. Most are products of the most recent retreat of the Cordilleran Ice Sheet in the Pleistocene (e.g., Howes, 1983; Clague and Ward, 2011). For further details about the geology of the Southwest Region see Northcote (2017).

3. Mines

The Southwest Region has one metal mine, one coal mine and numerous industrial minerals and aggregate operations (Fig. 1; Tables 1-3). Of eight large-scale industrial minerals operations in the region, two entered care and maintenance in 2016 and remained so in 2017. Aggregate operations in the region number in the hundreds and only the most prominent (e.g., those producing at least one million tpy) are reported here.

3.1. Metal mines

3.1.1. Myra Falls Operations (Nyrstar N.V.)

Myra Falls Operations is an underground polymetallic mine that exploits a cluster of volcanogenic massive sulphide lenses. Nyrstar suspended mining activities at the beginning of the

Table 1. Metal mines, Southwest Region.

Mine	Operator (partner)	Commodity; deposit type; MINFILE	Forecast 2017 Production (based on Q1-Q3)	Reserves	Resource	Comments
Myra Falls	Nyrstar Myra Falls Ltd. (parent co. Nyrstar N.V.)	Zn, Cu, Pb, Au, Ag; Noranda/Kuroko massive sulphide; 092F 072, 092F 330, 092F 071, 092F 073	na	P+Pr: 4.96 Mt 6.75% Zn, 0.72% Pb, 0.89% Cu, 71.01 g/t Ag, 1.71 g/t Au	M+I: 7.68 Mt 6.46% Zn, 0.69% Pb, 0.98% Cu, 68.99 g/t Ag, 1.74 g/t Au Inf: 1.03 Mt 8.80% Zn, 1.03% Pb, 0.85% Cu, 135.37 g/t Ag, 2.68 g/t Au	Resuming operations 2017-2018. Resources inclusive of reserves.

P = Proven; Pr = Probable; M = Measured; I = Indicated; Inf = Inferred

Table 2. Coal mines, Southwest Region.

Mine	Operator (partner)	Commodity; deposit type; MINFILE	Forecast 2017 Production (based on Q1-Q3)	Reserves	Resource	Comments
Quinsam	Quinsam Coal Corporation (ERP Compliant Fuels LLC)	TC; Bituminous coal; 092F 319	Approx. 50,000 t clean coal	na	na	Resources and reserves are unpublished. Resumed operations Sept 2017.

HCC = hard coking coal; PCI = pulverized coal injection; TC = thermal coal; ULV = ultra low volatile

P = Proven; Pr = Probable; M = Measured; I = Indicated; Inf = Inferred

second quarter in 2015. A \$100 million infrastructure upgrade is in progress with the goal of producing zinc by the second half of 2018 and ramping up to an annual rate of 30 kt/y of concentrate by the end of the year. The restart project includes: upgrading the H-W shaft and headframe; upgrading the paste plant; diamond drilling to increase resources and reserves; purchasing a new underground fleet; refitting and repairing the concentrator; constructing a new camp; and moving the power house. Infrastructure for hydroelectric power was upgraded.

Nyrstar now views its North American mines, including Myra Falls, to be a core part of the company's portfolio and do not appear to be actively seeking a buyer. Whereas current reserves and resources (Table 1) may be adequate for approximately 10 years at recent rates of mining, the company anticipates a longer operating life, pointing to exploration potential. A multi-year on-site exploration campaign, which was suspended in 2015, has resumed. Untested target areas remain in this camp, which so far consists of at least 7 significant deposits comprising at least 50 different sulphide lenses.

The deposits are hosted by the Sicker Group, a Middle Devonian volcano-sedimentary island-arc assemblage that forms basement to Wrangellia beneath much of Vancouver Island (Fig. 1). Ore bodies are in two horizons of the Myra Formation and are generally considered to have formed as Kuroko type, bimodal felsic volcanogenic massive sulphides.

3.2. Coal mines

3.2.1. Quinsam (ERP Compliant Fuels LLC.)

Underground coal mining on Vancouver Island dates back to 1849. The **Quinsam** thermal coal mine near Campbell River (Fig. 1) began operation in 1986 but went on care and maintenance in 2016. In 2017 the Vitol Group sold the mine. ERP Compliant Fuels LLC, is affiliated with Conuma Coal Resources Ltd., the company that resumed operations at Wolverine and Brule in northeastern British Columbia. Mining resumed in early fall and the wash plant was in operation shortly afterward. By late fall approximately 50 workers were on site. Production for 2017 was approximately 50,000 t of clean coal.

Table 3. Selected industrial mineral mines and quarries, Southwest Region.

Mine	Operator (partner)	Commodity; deposit type; MINFILE	Forecast 2017 Production (based on Q1-Q3)	Reserves	Resource	Comments
Apple Bay (PEM 100)	Linceo Media Group Inc.	Silica+alumina; R12:Volcanic glass-perlite; 092L 150	na	na	na	Care and maintenance 2017.
Benson Lake	Benson Lake Carbonates ULC	High brightness carbonate; R09:Limestone; 092L 295	na	na	na	Care and maintenance 2017.
Blubber Bay	Ash Grove Cement Company	Limestone, dolostone; R09:Limestone; 092F 479	24,500 t	na	100+ years	Care and maintenance, continues to ship dolomite on contract.
Garibaldi Pumice	Garibaldi Pumice Ltd.	Pumice; R11:Volcanic ash; 092JW 039	15,000 m ³	na	11,396,000 m ³ pumice 4,990,000 m ³ pumicite (fines)	2014 resource. Additional exploration 2015. Future work proposed and permitted.
Imperial Limestone	Imperial Limestone Co. Ltd.	Limestone; R09:Limestone; 092F 394	263,000 t	na	50+ years	Production number is their high quality product. Resource estimated at roughly 200 Mt.
K2	K2 Stone Quarries Inc.	Dimension stone, flagstone; R08:Flagstone; 092C 159	19,662 t	na	na	Number represents material extracted.
Mount Meager Pumice	Great Pacific Pumice Inc.	Pumice; R11:Volcanic ash; 092JW 039	2100 t	na	na	Sales about 1600 t.
Sumas Shale	Sumas Shale Ltd. (Lafarge Canada Inc., Clayburn Industrial Group)	Shale, clay, sandstone; B05:Residual kaolin; 092GSE024	Approx. 500,000 t	na	50+ years	Approximately 55% shale, 45% sandstone for cement production.
Texada Quarry	Texada Quarrying Ltd. (Lafarge Canada Inc.)	Limestone, aggregate; R09:Limestone; 092F 395	na	na	100+ years	Mostly produces limestone for cement manufacture. High brightness carbonate and aggregates also produced.

P = Proven; Pr = Probable; M = Measured; I = Indicated; Inf = Inferred

Currently the only underground coal mine in the province, the **Quinsam** mine produces from coal seams in the upper part of the Comox Formation, the basal unit of the Nanaimo Group (Late Cretaceous). The mine is capable of producing more than half a million tonnes a year. ERP Compliant Fuels is a private company that does not release reserve and resource

figures. The mine has a significant potential resource. Product is blended to meet customers' specifications. Most recently, the mine supplied local cement plants. The mine can also serve international markets using a freighter loading facility on Texada Island.

3.3. Selected industrial minerals and aggregates mines

Large quarries on the coast (Table 3) serve the Lower Mainland, Vancouver Island, and U.S. Pacific northwest markets by barge. Those with access to freighter loadout facilities can also supply eastern Pacific international markets, and Hawaii. Aggregates are an important part of the mining industry on the south coast, generating more jobs in the region than metal and coal mining. The area hosts some of the largest aggregate pits and quarries in Canada. Most quarries serve local markets, although a few of the largest also export. General sales and production trends follow those of the construction industry. Lafarge North America, Lehigh Hanson Materials Ltd. and a local company Mainland Sand and Gravel Ltd. are the three largest participants in the Coast area, although hundreds of pits and quarries produce in the region.

One of the largest aggregate-only mines is the **Sechelt Mine**, operated by Lehigh Hanson. The company no longer makes production figures public, but volumes have been in the 5 million tonne range in recent years. It is permitted for up to 7.5 Mt per year. A loading facility capable of accommodating Panamax class freighters handles most of the shipments. In addition to the **Texada Quarry**, Lafarge North America operates two of the largest aggregate quarries in the region (**Earle Creek** and **Pitt River**) each of which typically produces more than 1 Mt per year. Production and employment estimates for 2016 reported by Lafarge for their four largest aggregate operation serving the Lower Mainland include: 1.0 Mt and 23 people at **Earle Creek**, 1.1 Mt and 21 people at **Pitt River Quarry**; 1.0 Mt and 17 people at **Central Aggregate**; and 0.9 Mt and 10 people at **Ward Road**. Remediation work continues at Lafarge's **Pipeline Road** site. In total 4 Mt were produced and 77 people employed at these operations alone.

Near the **Pipeline Road** site are large operations by Jack Cewe Ltd and Allard Contractors Ltd. Together they produce in excess of one million tonnes per year most years. Cewe also operates a large quarry on Jervis Inlet at Treat Creek. They do not release yearly production figures.

Polaris Materials Corporation operates the **Orca** quarry near Port McNeill, which produces sand and gravel mainly for export (Fig. 2). Polaris Materials anticipates full-year 2017 sales of



Fig. 2. A scraper at the Orca quarry.

3.2 to 3.4 tons (about 3 t). In November 2017, shareholders of Polaris Materials Corporation, approved an offer from U.S. Concrete Inc. to purchase Polaris. An arrangement agreement with Vulcan Materials Company was cancelled. Polaris has meanwhile applied to the BC Environmental Assessment Office for an amendment to its Orca project certificate to allow for aggregate production at a site approximately 4 km from current operations. The new site was previously known as the Black Bear project. This site would supply up to 250,000 tpy of a crushed basalt product.

The **Cox Station** quarry, on the north side of Sumas Mountain, is operated by Mainland Sand and Gravels Ltd. More than 95% of the crushed quartz diorite product goes to the Lower Mainland market via barge on the Fraser River. The quarry also has two CN Rail spur lines, which allow shipment by rail. Production and shipments have recently been 2-3 Mt per year. The quarry employs 45-50 people.

Small operations produce building stone on Vancouver Island. Van Isle Slate Ltd. offers a line of hand-cut slate products quarried from rocks of the Leech River complex. The quarry had minor production in 2016 and the owner expected to produce again in 2017. Island Stone Landscape Supply is another established producer and supplier of flagstone, as is San Juan Quarries. Matrix Marble and Stone Inc. continues to quarry marble on Vancouver Island and fabricate a line of products including countertops, sinks, and tiles. They quarry Tlupana Blue Grey and Vancouver Island White marble near Hisnit Inlet.

Landscaping stone and dimension stone is quarried in the Squamish-Whistler corridor. The largest operator is Northwest Landscape and Stone Supply, with the Spumoni quarry and their Cabin Group property, which now has a Mines Act quarry permit. Others active in the area include Bedrock Granite Sales Ltd., Citadel Stone Ltd., and Alpine Natural Stone Ltd.

Haddington Island and Hardy Island have been two regular suppliers of dimension stone on the coast. The Haddington Island product (typically referred to as Haddington Island andesite) is a durable, resistant dacitic volcanic rock (70.5% silica), part of the Alert Bay volcanic belt (Neogene). Adera Natural Stone Supply Ltd. supplied Haddington Island stone for a new porte cochere at the Fairmont Empress Hotel, but there was no new quarrying in 2017. The quarry supplies stone as needed and may operate in 2018. Most of the product is used in restoration work on historic buildings, but it has also been used in modern monuments and buildings.

Hardy Island Granite Quarries Ltd. produces from a uniform grey Coast Plutonic complex granodiorite unit. Like Haddington Island, it is an historic quarry that mainly serves the local market. By the end of 2017, it will have produced about 3800 t. Hardy Island has opened another quarry on Valdes Island that supplies sandstone from the Nanaimo Group, another rock type that can be found on many older buildings in Vancouver and Victoria. Response to test marketing appears to be positive and production in 2016 was about 1500 t. They

shipped from stockpiles in 2017 and plan to quarry again in 2018.

3.3.1. Texada (Texada Quarrying Ltd.)

The largest limestone quarry on the coast is the **Texada Quarry** operation near Gillies Bay. Texada Quarrying Ltd. is a subsidiary of Lafarge Canada Inc. The quarry also produces aggregate, mainly from quartz monzonite to gabbro dikes and sills, which would otherwise be waste rock. The site also hosts a white carbonate quarry, one of only a few sources on the coast. The quarry, which has operated for more than 60 years, has extensive reserves and, at current rates, is capable of producing for more than 100 years.

3.3.2. Imperial Limestone (Imperial Limestone Co. Ltd.)

In recent years, the **Imperial Limestone** quarry near Van Anda on Texada Island (Fig. 1) has produced approximately 250,000 to 270,000 tpy of high-purity product. In 2017 they expect to produce about 290,000 tons (263,000 t), most of which will be shipped to their parent company in Seattle. They also mine and stockpile a larger quantity of lower quality limestone. Quarrying at the Imperial site dates back to the 1930s, and the current owners have operated it since the early 1950s. They anticipate reserves will last for more than 50 years.

3.3.3. Blubber Bay Quarry (Ash Grove Cement Company)

The **Blubber Bay** limestone quarry on Texada Island has remained mostly on care and maintenance since 2010, after more than 100 years of operation. It reopens for sufficiently large contracts. It can still supply limestone aggregate and continues to supply dolomite. It barged about 24,500 t of dolomite to Ash Grove's Rivergate Limestone Plant in Oregon in 2017. It has a contract for 150,000 t and plans 75,000 tpy during the next two years.

3.3.4. PEM 100 (Linceo Media Group LLC)

On northern Vancouver Island, the new operator of the **PEM 100** or **Apple Bay** quarry, Linceo Media Group LLC, left the site on care and maintenance, but with environmental monitoring ongoing. When operating, the quarry ships silica and alumina products from silicified and clay-altered rhyolitic flows and volcanoclastic rocks. Ash Grove Cement Company and previous quarry operator Electra Stone Ltd. conducted mine site exploration programs to better define its resources and to identify higher-silica (>97% SiO₂) material in 2015-2016. The new operator is proposing exploration and a higher production rate, pending discussions with the lease holder.

3.3.5. Benson Lake (Benson Lake Carbonates ULC.)

At the **Benson Lake** white carbonate deposit on northern Vancouver Island, new owner Benson Lake Carbonates ULC reported 2016 production totalling approximately 19,000 t. In 2017, the quarry was on care and maintenance. The new owner expects to suspend production for 1-2 years but may conduct

some on-site exploration. The high-brightness product is used mainly as white filler.

3.3.6. Sumas Shale (Sumas Shale Ltd.)

The **Sumas Shale** quarry of Sumas Shale Ltd., operated by contractor Fraser Pacific Enterprises Inc., delivers sandstone and shale product to the Lafarge and Lehigh cement plants in Richmond, and Ash Grove in Seattle. Sumas Shale Ltd is 50% owned by Lafarge Canada Inc. and 50% by Clayburn Industrial Group. Production and shipments have been approximately 500,000 tpy in recent years and a similar quantity is anticipated for 2017, with sales projected at 550,000 t. In future they plan to mine an average 475,000 tpy of approximately 55% shale and 45% sandstone. Because Clayburn's brick and refractory products plant in Abbotsford closed, fireclay is no longer produced separately.

3.3.7. Bute Inlet (Ironwood Clay Company Inc.)

Ironwood Clay Company Inc. mines glacial marine clay on the central Coast. Until 2015, production had been from the **DeCosmos Lagoon** south of Bella Bella (Fig. 1). They have a new site at the head of **Bute Inlet**, which is likely to supply future raw material. They collected approximately 595 t there in 2017. Ironwood produces cosmetic products using the clay at its Richmond plant, a business that has continued for 29 years. Other individuals and companies supply the growing cosmetic clay market at smaller scales from locations on the central Coast and Vancouver Island. Glacial Bay Organic Clay Inc. is extracting material by hand, also near the head of Bute Inlet. Generally, Mines Act permits are not required where material is collected by hand, and therefore some glacial marine clay operations are unreported.

3.3.8. Garibaldi Pumice and Mount Meager Pumice (Garibaldi Pumice Ltd., Great Pacific Pumice Inc.)

In the Mount Meager area, Garibaldi Pumice Ltd. produced 15,000 m³ of pumice from the **Garibaldi Pumice** quarry in 2017 (similar to 2015 and 2016) and reported strong sales. Exploration on the property consisted of 12 test pits to further delineate the existing resource (Table 3).

Neighbouring Great Pacific Pumice Inc. produced about 2100 t in 2017 at their **Mount Meager** quarry, and sold about 1600 t. They have stockpiles in Squamish from which they can ship year-round.

3.3.9. K2 (K2 Stone Quarries Inc.)

K2 Stone is a natural stone product supplier with a quarry near Port Renfrew on Vancouver Island (**K2**). They extracted 19,662 t in 2017. The rock is trucked to Nanaimo for processing into masonry and landscaping products.

4. Placer gold

Historic placer camps include the Lower Fraser River, Leech River, and China Creek. Although short lived, a gold rush in the

Fraser Canyon, beginning in 1858 at Hills Bar, led lead miners farther up the Fraser River into the Chilcotin and Cariboo. In 1864, reports of gold in the Leech River on southern Vancouver Island led to another brief gold rush. Both camps are worked by placer miners to the present day. There was one permit amendment on the Leech River in 2017 and a permit issued on the Lillooet River. Many placer miners operate with multi-year permits.

5. Mine development

Mine development projects are those for which a decision to produce has been made, key government approvals are in place, and on-site construction has begun. The Southwest Region has no such projects.

6. Selected proposed mines

Proposed mines are feasibility-stage projects for which proponents have begun the environmental certification process (in the case of large projects) or have submitted applications for Mines Act permits (in the case of projects below British Columbia Environmental Assessment Act thresholds). The Southwest Region has four such projects (Table 4); several small-scale and inactive larger projects are not covered in this report.

6.1. Proposed metal mines

The Southwest Region had no proposed major metal mine projects active in 2017.

6.2. Proposed coal mines

In 2016, the BC Environmental Assessment Office terminated environmental assessment of the Raven Underground Coal

mine project of Compliance Coal Corporation, and the region now has no active proposed coal mine projects.

6.3. Selected proposed industrial minerals mines

Proposed mines include the **BURNCO Aggregate** Project and the **Sechelt Carbonate** project, which has been inactive apart from a request by the owner to remain in the provincial environmental assessment process. The **Black Bear** aggregate project near Port McNeill is subject of an application to amend the Orca permit. Callache Stone Quarries Inc. has applied for a quarry permit for its **Tahsis** marble project.

6.3.1. BURNCO Aggregate (BURNCO Rock Products Ltd.)

The **BURNCO Aggregate** Project in the McNab Creek Valley (Fig. 1) submitted its application for environmental assessment with both provincial and federal agencies in 2016. The BC Environmental Assessment Office issued a draft Summary Assessment Report in October 2017 and a public comment period on the report followed. The proposed sand and gravel mine would ramp up to a 1.6 Mt per year operation, initially barging product to BURNCO Rock Products Ltd.'s ready-mix concrete plants in South Burnaby and Port Kells. BURNCO submitted revisions to the project in 2014, changing production rate, relocating some facilities and specifying a mine life of 16 years. Design modifications continued into the review phase to mitigate identified effects.

6.3.2. Sechelt Carbonate (Ballinteer Management Inc.)

Ballinteer Management Inc. now holds the property comprising the **Sechelt Carbonate** project. They filed engineering, archeological, and baseline environmental studies for assessment in 2016; no activity was reported for 2017.

Table 4. Selected proposed mines or quarries, Southwest Region.

Project	Operator (partner)	Commodity; deposit type; MINFILE	Reserves	Resource	Comments
Black Bear	Polaris Materials Corporation	Aggregate; R15; n/a	na	na	Orca environmental certificate amendment for an adjacent quarry applied for.
BURNCO Aggregate	BURNCO Rock Products Ltd.	Aggregate; B12:Sand and Gravel; n/a	na	Approx. 20 Mt	Late in environmental assessment review.
Sechelt Carbonate	Ballinteer Management Inc.	Limestone, dolostone, aggregate; R09:Limestone; R10:Dolomite; R15:Crushed rock; 093GNW031	na	Carbonate Rock: 76.1 Mt Gabbro: >700 Mt	Environmental assessment pre-application.
Tahsis	Callache Stone Quarries Inc.	Marble; R09; 092E 020	na	na	Quarry permit and lease application for commercial production.

P = Proven; Pr = Probable; M = Measured; I = Indicated; Inf = Inferred

After a period of quiescence, Ballinteer indicated an interest in advancing the project, which entered the pre-application phase of environmental assessment in 2005 under different ownership. The property contains resources of both calcite- and dolomite-bearing carbonate rock and gabbroic rock for potential use as aggregate.

6.3.3. Black Bear (Polaris Materials Corporation)

As noted above, Polaris Materials Corporation is including **Black Bear** near its **Orca** sand and gravel quarry in an environmental certificate amendment for Orca. If the project proceeds, it will be a source of up to 250,000 tpy of crushed basalt.

6.3.4. Tahsis (Callache Stone Quarries Inc.)

Callache Stone Quarries Inc. is applying for a quarry permit and lease near Tahsis (**Tahsis** quarry) and intend to enter commercial production. Meanwhile they continue with surface preparation, bulk sampling, testing, and marketing.

7. Selected exploration activities and highlights

Exploration projects are categorized as grassroots, early-stage, advanced or mine evaluation, depending upon the nature of recent work. Work directed at discovering new resources away from ore bodies in an existing mine plan can be considered mine-lease or on-site exploration. The Southwest Region had few large exploration programs in 2017 (Table 5).

7.1. Selected precious metal projects

Precious metal prospects are found in a variety of settings in the region. There was one major exploration project in 2017, in addition to several smaller projects.

7.1.1. Goldstar (DSM Syndicate)

Grab samples taken during reconnaissance prospecting south of Bella Coola returned high-grade gold values from sulphide bearing quartz veins. Out of 16 samples, 6 had values of interest and 4 samples returned more than 10 g/t Au with Ag, Cu and Pb values. This area has no record of previous exploration. Goliath Resources Ltd. holds 10% of DSM Syndicate and Juggernaut Exploration Ltd. 20%.

7.1.2. Eliza (Caisey Harlinton)

At the **Eliza** gold prospect, owned by Caisey Harlinton, a hand-held drilling program, started in 2016, is testing gold-bearing veins near historical workings. Additional drilling is permitted. In 1940, 12.7 tonnes of ore yielded 435 grams of Au with Ag and Cu by products. The area was also explored in the 1980s.

7.1.3. Surespan Gold (640895 B.C. Ltd.)

A numbered company doing business as Surespan Gold, drilled approximately 6000 m in the Privateer area near Zeballos. The project is privately funded and results have not been made public. The company expects to return to

exploration in 2018. The area is underlain mainly by Jurassic basaltic to rhyolitic volcanic rocks of the Bonanza Group, and Eocene intrusive rocks. Between 1934 and 1975, the Zeballos camp (Figs. 3, 4) produced approximately 300,000 oz Au from

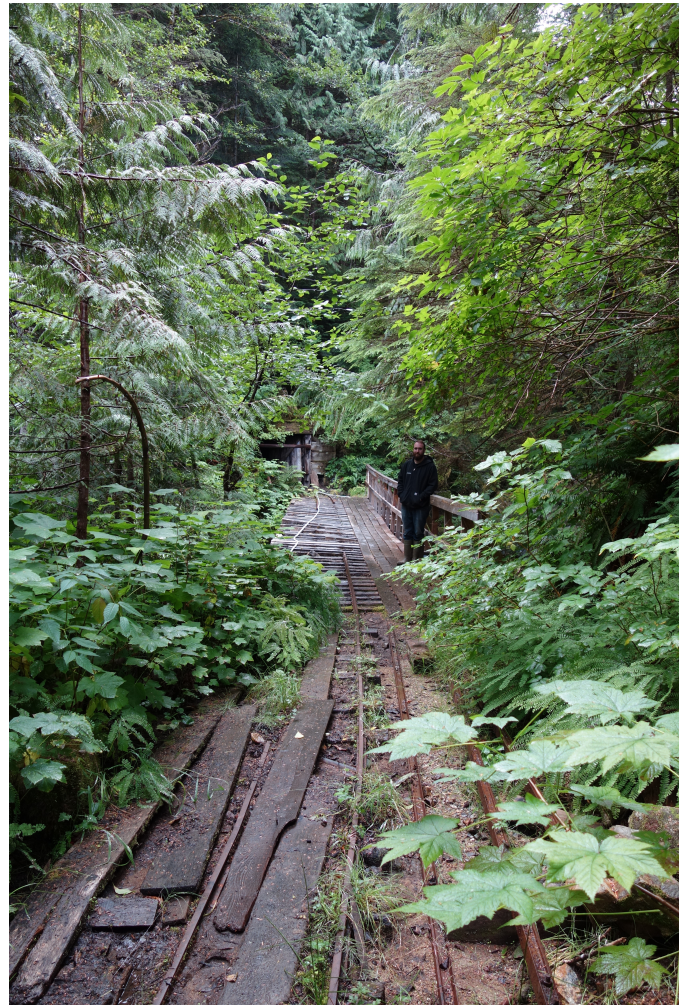


Fig. 3. Surespan project, in front of the portal of the historic Privateer mine.



Fig. 4. The Zeballos River valley looking south west. The historic mining camp spanned the river, with most mines southeast of the river (left of frame).

Table 5. Selected exploration projects, Southwest Region.

Project	Operator (partner)	Commodity; Deposit type MINFILE	Resource (NI 43-101 compliant unless indicated otherwise)	Comments
Ashlu	Ashlu Mines Inc.	Au, Ag, Cu; Polymetallic veins; 092GNW013	na	Multi-year geology, geochemistry and geophysics continued. Property surrounds the Ashlu past producing mine.
Dancer Group	AMA Gold Exploration Ltd.	Au, Ag; Au-quartz veins; 092GNW008, 092GNW012	na	Permitting, archaeology, metallurgy.
Eliza	Caisey Harlington	Au, Ag, Cu; Cu±Ag quartz veins; 092E 043	na	Portable diamond drilling.
Fandora	Imperial Metals Corporation	Au, Ag; Cu±Ag quartz veins; 092F 040 092F 041 092F 205	Historical: 180,000 t 10.3 g/t Au	Mapping, soil and rock geochemistry.
Giant Copper	Imperial Metals Corporation	Cu, Au, Ag, Mo; Porphyry Cu±Mo±Au; 092HSW001 092HSW002 092HSW027 092HSW161	Invermay zone I: 17,532,570 tons 0.226% Cu, 0.011 oz/t Au, 0.310 oz/t Ag AM Breccia zone Historical: 29,523,030 tons 0.653% Cu, 0.11 oz/t Au, 0.360 oz/t Ag, 0.007% Mo	Access, soil and rock geochemistry.
Goldstar	DSM Syndicate	Au, Ag, Zn, Cu	na	Prospecting, sampling. Discovery of gold mineralization.
Jasper	Nitinat Minerals Corporation	Cu, Zn, Au, Ag; Noranda/Kuroko massive sulphide; 092C 080 092C 037 092C 081 092C 088	na	Geophysical interpretation.
Jordan River	New Sunro Copper Ltd.	Cu, Au, Ag; Tholeiitic intrusion-hosted; 092C 073	Historical: 1.4 Mt 1.4% Cu	Permitting.
Ladner Gold	New Carolin Gold Corp.	Au, Ag; Au- quartz veins; 092HWN003 092HWN007 092HWN018 092HSW034	Carolyn Inf: 12,352,124 t 1.53 g/t Au McMaster Inf: 3,575,000 t 0.69 g/t Au Tailings I: 445,378 t 1.83 g/t Au Inf: 93,304 t 1.85 g/t Au	Underground rehabilitation and preparation for drilling.

Table 5. Continued.

Myra Falls	Nyrstar N.V.	Zn, Cu, Pb, Au, Ag; Noranda/Kuroko massive sulphide; 092F 330 092F 071 092F 072 092F 073	See Table 1	On-lease exploration drilling began late in 2017.
North Island	Northisle Copper and Gold Inc.	Cu, Au, Mo; Porphyry Cu±Mo± Au; 092L 240 092L 200	Red Dog I: 23.6 Mt 0.32% Cu, 0.46 g/t Au Hushamu I: 304 Mt 0.21% Cu, 0.29 g/t Au, 0.01% Mo Inf: 205.6 Mt 0.18% Cu, 0.26 g/t Au, 0.008% Mo	Diamond drilling (1800 m in 6 holes), preliminary economic assessment.
OK	Lorraine Copper Corp.	Cu, Mo; Porphyry Cu±Mo± Au; 092K 008 092K 057 092K 168	Inf: 86,800,000t 0.31% Cu, 0.014% Mo	Induced polarization survey started.
Port Renfrew Block	Pacific Iron Ore Corporation	Clay; Surficial; na	na	Investigation of extensive glacial lacustrine clay deposits.
Prosper	New Sunro Copper Ltd.	Au, Ag, Cu; Cu±Ag quartz veins; 092F 053	Historical: 8150 t 32 g/t Au	Permitting, litho-geochemistry.
Tahsis	Callache Stone Quarries Inc.	Marble; 092E 020	na	Permitting, surface preparation, bulk sampling.
Skull Lake	BC Marble Products Ltd.	Marble; 092F 414	na	Bulk sample.
Surespan Gold	640895 B.C. Ltd.	Au, Ag; Au-quartz veins; 092L 008	Privateer Historical: 122,475 t 17 g/t Au	Privateer mine area. Approximately 6000 m diamond drilling.
Turnour Island	New Sunro Copper Ltd.	Cu, Au; na; na	na	Recent discovery of copper-bearing quartz stockwork veining.
Valentine Mountain	Great Thunder Gold Corp.	Au, Ag; Au-quartz veins; 092B 108 092B 183 092B 185	I: 54,763 t 16.3 g/t Au Inf: 20,700 t 22.6 g/t Au	2013 resource estimate includes Discovery B,C, E and Discovery West C vein. 2017 field work was soil and stream moss mat geochemistry.

M = Measured; I = Indicated; Inf = Inferred

veins, mostly at the Privateer and Spud Valley mines. The last significant exploration was in the early 2000s.

7.1.4. Fandora (Imperial Metals Corporation)

Imperial reported mapping, soil, and rock geochemistry in the vicinity of the historic **Fandora** mine. This follows geochemical sampling in 2016. Discovered in the 1930s, Fandora produced 972 t between 1960 and 1964, yielding 45,660 g Au. It has an historical resource of 180,000 t at 10.3 g/t Au.

7.1.5. Prosper (New Sunro Copper Ltd.)

New Sunro plans to re-activate a prospect explored by Bralorne Mines Ltd. in the 1940s. The historical program produced 90 t yielding 6687 g Au with Ag and Cu. In addition to geochemical sampling, New Sunro filed a Notice of Work for drilling. Rock samples confirm gold in quartz veins (the highest 124.53 g/t Au, 115 g/t Ag). Lead isotope analysis suggested that sulphides are Eocene.

7.1.6. Valentine Mountain (Great Thunder Gold Corp.)

Great Thunder Gold Corp. reported soil sampling and sampling of moss mats in streams at its **Valentine Mountain** Property on southern Vancouver Island. The moss mat sampling was over an area of 2000 by 500 m on the northern flank of Valentine Mountain. The soil samples were from Discovery West zone, 600 m west of the Discovery zone. The property was last drilled in 2012 and resource estimates were prepared in 2013.

7.1.7. Dancer Group (AMA Gold Exploration Ltd.)

AMA Gold's 2017 work included metallurgy and an archaeological impact study. Drilling, trenching, and bulk sampling was permitted late in the year. They have an agreement with Nicola Mining Inc. to process the bulk sample.

7.1.8. Ashlu (Ashlu Mines Inc.)

Ashlu Mines Inc. is a private company that has assembled a land position near the former Ashlu Mine near Squamish (**Ashlu property**). In 2017, they reported continuing geology and geochemistry at the property. A multi-year geological, geophysical (VLF-EM), and geochemical (rock, soil, and silt sampling) program that began in 2009 and continued annually since 2011, has relocated showings near the former mine. The Ashlu Mine, not part of this project, is a past producer that exploited a narrow (<1 to 4.6 m) gold-bearing quartz vein along a strike length of 90 m and extending 85 m down dip. In 1981 reserves were just less than 90,000 t of 8.57 g/t Au and 12.31 g/t Ag. The principal target of the surrounding project is mineralization similar to the Ashlu Mine. The property is largely underlain by the Clodburst pluton (Jurassic).

7.1.9. Ladner Gold (New Carolin Gold Corp.)

New Carolin Gold Corp. completed its acquisition of the **Ladner Gold** project in 2016 and now holds 100% of the property, including the former Carolin Mine site (subject to percentage of net smelter returns royalty). Following a surface program in 2016, 2017 work included preparing for underground drilling with a survey of workings, upgrades, and re-forestry. Before the recent surface drilling, the company had resource estimates at the past-producing Carolin mine (Fig. 5) for an open pit operation of Inferred at 0.5 g/t cutoff of 12,352,124 t grading 1.53 g/t Au and for an underground operation of Inferred at 2.0 g/t cutoff of 2,588,376 t grading 3.34 g/t Au.

The McMaster zone has an Inferred resource of 3,575,000 t grading 0.69 g/t Au at a 0.5 g/t Au cut off. The Carolin Mine tailings estimate has 445,378 t at 1.83 g/t Au in the Indicated category and 93,304 t grading 1.85 g/t in the Inferred category. Late in 2016, New Carolin began a second underground phase of their program which continued in 2017, including underground rehabilitation, channel sampling and geological mapping.

New Carolin has surrounding tenures covering much of the Coquihalla gold belt, a north-northwest trending series of gold



Fig. 5. View of the Carolin mine area from the tailings pond. The main resource is in the logged area.

occurrences between Sowaqua and Siwash Creeks, which has generally not been well explored by modern methods. Veins of economic interest are found in sedimentary and mafic volcanic rocks northeast of the East Hozameen fault and Coquihalla serpentine belt.

7.2. Selected porphyry (Cu-Au, Cu-Mo, Mo) projects

The region's most advanced porphyry project, the North Island Project, is focused on Jurassic mineralization. In addition, southwestern British Columbia has several advanced Eocene to Miocene porphyry copper targets. Two of these, OK and Giant Copper, saw modest levels of exploration in 2017.

7.2.1. North Island Project, Red Dog and Hushamu (Northisle Copper and Gold Inc.)

Between 1971 and 1994, the Island Copper mine produced 345 Mt with average head grades of 0.41% Cu, 0.017% Mo, and 0.19 g/t Au. Several porphyry copper and epithermal gold targets extend along a 40 km west-north-west trend from Island Copper. **Hushamu**, a copper-molybdenum-gold porphyry prospect, is the most advanced, with Indicated 304 Mt of 0.21% Cu, 0.29 g/t Au, 0.010% Mo, and 0.56 ppm Re and Inferred 205.6 Mt of 0.18% Cu, 0.26 g/t Au, 0.008 % Mo and 0.38 ppm Re. In 2015, Northisle Copper and Gold Inc. acquired an option on the **Red Dog** property, approximately 7.5 km west-north-west of the Hushamu deposit. In 2016, they drilled to verify a historical resource estimate. At a 0.20% Cu cut off, the updated Red Dog estimate has 23.6 Mt at 0.32% Cu, 0.46 g/t Au and 0.007% Mo Indicated and 848,000 t at 0.23% Cu, 0.33 g/t Au and 0.003% Mo Inferred. The Red Dog and Hushamu resources together were subject of a 2017 preliminary economic assessment, which modelled a 75,000 tpd open-pit operation with a 22-year life. The base case had an after tax net present value of \$550.5 million applying a discount rate of 8%. The internal rate of return is estimated at 14.3%. Initial capital costs were estimated at \$1.34 billion. The project would benefit from existing infrastructure in the area (Fig. 6).

Drilling in 2017 (1800 m in 6 holes) included testing a



Fig. 6. Cape Scott wind farm looking north from North Island porphyry project.

southeastern extension of the Hushamu deposit, testing an area in the Hushamu deposit previously considered occupied by late or post-mineral breccia and barren, and testing for deep mineralization at Red Dog. Mineralization at Hushamu does appear to be open to the southeast and north and the infill drilling encountered mineralization above cut off. The hole at Red Dog was lost before reaching target depth but did encounter porphyry style alteration and increasing mineralization at depth.

Mineralization also remains open on Northisle's tenures to the west. A separate mineralized zone, 400 m east of the Red Dog zone, has been reported. Since it was detected as a geochemical anomaly in 1962, Red Dog has seen more than 9000 m of reported drilling. Hushamu, Hep, Red Dog and a 2005 discovery, NW Expo, form a roughly 10 km west-northwest trending series of porphyry occurrences. The former Island Copper mine is approximately 30 km east-southeast.

7.2.2. OK (Lorraine Copper Corp.)

Lorraine Copper Corp. acquired 100% of the **OK** copper-molybdenum prospect north of Powell River in 2016. Late in 2017, they began an induced polarization survey. Known mineral occurrences extend along a roughly 5 km north-northwest trend. The northernmost, North Lake Zone, has an Inferred resource of 86.8 million tonnes grading 0.31% Cu and 0.014% Mo. The mineralization is open with untested step-out geophysical and geochemical drill targets.

7.2.3. Turnour Island (New Sunro Copper Ltd.)

New Sunro reports copper mineralization in stockwork quartz veins in intrusive rocks on Tournour Island. Results of prospecting and rock, stream sediment, and moss-mat sampling were filed for assessment. The showing was discovered during recent logging operations. An initial grab sample returned 1.38% Cu, 8.0 g/t Ag, 0.599 g/t Au. A follow up sample was similar, grading 0.876% Cu, 4.8 g/t Ag, 0.469 g/t Au. There is no record of previous mineral exploration on Turnour Island, although several volcanic redbed-type showings are documented on nearby islands and neighbouring Harbledown Island hosts a limestone prospect.

7.2.4. Giant Copper (Imperial Metals Corporation)

Imperial reported work on access and soil sampling and lithogeochemistry. This follows sampling in 2016, which delineated a 250 x 400 m gold in soil anomaly. There is a 2006 resource estimate on the Invermay zone of 17,532,570 tons at 0.226% Cu, 0.011 oz/t Au and 0.310 oz/t Ag Indicated. Giant Copper also has historical resources for the AM breccia zone. The open pit estimate is 29.5 Mtons at 0.653% Cu, 0.11 oz/t Au, 0.360 oz/t Ag, and 0.007% Mo. The historical underground estimates are 2.6 Mtons at 1.223% Cu, 0.017 oz/t Au, 0.626 oz/t Ag, and 0.005% Mo; and 1,234,500 t at 1.155% Cu, 0.013 oz/t Au, 0.682 oz/t Ag, and 0.024% Mo historical inferred (non-compliant).

7.3. Selected polymetallic base and precious metal projects

With the notable exception of a program at Myra Falls, volcanogenic massive sulphide deposits in the southwest saw limited exploration in 2017.

7.3.1. Jasper (Nitinat Minerals Corporation)

Nitinat filed 2017 geophysical work for assessment. Results, which include an inversion of electromagnetic data, remain confidential.

7.4. Selected mafic and ultramafic associated projects

Mafic- and ultramafic-associated deposits are known in the Metchosin complex on southern Vancouver Island and in assemblages in the Harrison Lake-Hope area (e.g., Giant Mascot intrusion), which hosted British Columbia's only significant nickel producer.

7.4.1. Jordan River (New Sunro Copper Ltd.)

New Sunro Copper Ltd., a private company, reported no new technical work, but obtained a permit to drill their Jordan River project, site of the Sunro past producer. Recent work included underground remediation, mapping, historical data compilation, and airborne geophysics. The first phase of drilling, now permitted, would be from surface. Classed as a magmatic deposit, sulphide mineralization is reported mainly in shear zones, fractures, shatter zones in Metchosin complex basalt, close to gabbroic sills. Some mineralized samples

from the site were anomalous in nickel, cobalt, and palladium but copper, gold and silver are the commodities found in economic concentrations to date. Two orebodies were mined intermittently from 1962 to 1974. Between 1962 and 1978 the mine produced 13,754 t Cu, 203,101 g Au and 2,262,651 g Ag from 1.3 Mt of ore. Exploration has been modest and limited to surface surveys since mining ceased in 1974. The last reported historical resource estimate was in 1973. At that time 1,030,465 t grading 1.47% Cu were in proven and 423,782 t grading 1.33% Cu in probable categories.

7.5. Selected industrial minerals and aggregates projects

Exploration for industrial minerals and aggregates is commonly carried out by individuals and private companies and typically goes un-reported. Of the more than 600 quarry and sand and gravel operations with active permits not all are currently producing or conducting investigative work.

7.5.1. Port Renfrew Block (Pacific Iron Ore Corporation)

The company filed work for assessment (prospecting, geology, and geochemistry) in 2017. The Loss Creek area has deposits of glacial lacustrine clay that are being investigated to determine their commercial potential.

7.5.2. Skull Lake (BC Marble Products Ltd.)

BC Marble Products continued their bulk sample at their marble prospect near Skull Lake in 2017. Limestone was quarried nearby at Pipestem Inlet in the Early 20th century.

8. Geological research

The digital geology map of British Columbia (Cui et al., 2017) has been updated to include mapping in northern Vancouver Island by Nixon et al. (2011). Heberlein et al. (2017a, b) reported an investigation of halogens and other volatile compounds as indicators of mineralization. The study areas include the Lara polymetallic VMS prospect and the Mount Washington epithermal Au-Cu-Ag prospect, both on Vancouver Island.

Jackaman (2017) presented results of an RGS sample reanalysis project that includes NTS map sheet 092N. Geoscience BC (2017) released maps, reports and other data relating to Mount Meager geothermal energy potential (Project 2017-006).

9. Summary

In 2017, the most positive news in the region was both Myra Falls and the Quinsam mine being reactivated. Both have traditionally carried out exploration programs and, in the case of Myra Falls, this work has already begun. The North Island porphyry project released its first public preliminary economic assessment study. What started as a fairly modest drill program in the Zeballos camp expanded over the course of the year and could continue into 2018. Two significant industrial minerals quarries on Northern Vancouver Island remained on care and maintenance.

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